

BIGHORN SHEEP MANAGEMENT PLAN:
CADY MOUNTAINS MANAGEMENT UNIT*

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INTRODUCTION

In 1986, Assembly Bill (AB) 3117 was enacted by the California Legislature. That legislation amended Section 4700, and added Sections 4900-4904, to the California Fish and Game Code (Code). The legislature declared that the bighorn sheep is an important wildlife resource in California, and is to be managed and maintained at sound population levels. It also directed the Department of Fish and Game to prepare a management plan for each population (herd) of bighorn sheep in California. In addition, it authorized, for the first time in 108 years, very limited and carefully regulated harvest of mature rams.

In 1991, AB 977 was enacted by the legislature, and expanded the hunting program. In accordance with that legislation, it is the policy of the Department of Fish and Game to (1) maintain, improve, and expand bighorn habitat where feasible; (2) reestablish populations of bighorn sheep on historic ranges where feasible; (3) increase bighorn populations to levels such that no subspecies nor distinct population segment requires classification as threatened or endangered; and (4) encourage and provide for esthetic, educational, and recreational uses of bighorn sheep, as appropriate.

Overall statewide management goals and recommended actions are discussed in detail in the current management plan for bighorn sheep (California Department of Fish and Game 1983). This management plan has been prepared specifically for the Cady Mountains Bighorn Sheep Management Unit. It is intended to comply with legislative policy as set forth in Sections 1801 and 4900-4904 of the California Fish and Game Code, which mandate that management plans be prepared for each bighorn sheep management unit, and that those plans provide information on (1) the numbers, age, sex ratios, and distribution of bighorn sheep within the management unit; (2) range conditions and a report on the competition that may exist as a result of human, livestock, wild burro, or any other mammal encroachment; (3) the need to relocate or reestablish bighorn populations; (4) the prevalence of disease or parasites within the population; and (5) recommendations for achieving the policy objective of Section 4900.

LOCATION

The Cady Mountains Management Unit is located in the central Mojave Desert, and is centered approximately 50 km east of the city of Barstow, San Bernardino County. The management unit is bounded on the south by Interstate Highway 40, on the east by Crucero Road and Zzyzx Road, and on the north by Interstate Highway 15.

HABITAT DESCRIPTION

Elevations on the Cady Mountains Management Unit range from approximately 315 m in the northeastern portion of the unit to 1,411 m at the highest point in the Cady Mountains. Weaver et al. (1969) described much of the area as volcanic in origin, except for alluvial badlands along Afton Canyon in the north end of the Cady Mountains. Those authors also noted the presence of substantial areas of blow-sand between Hidden Valley, in the central portion of the Cady Mountains, and Afton Canyon.

Weather conditions in this management unit are typical of the Mojave Desert. Daytime high temperatures in summer frequently exceed 38° C, and temperatures below freezing in winter are not uncommon (Weaver et al. 1969). Precipitation in the vicinity of the management unit averages 10 cm annually, with about half of it falling as summer showers (Freiwald 1984), which are extremely localized throughout the Mojave Desert and within the management unit. As a result, annual precipitation within the unit varies considerably.

The majority of the Cady Mountains Management Unit is in public ownership and is administered by the Bureau of Land Management (BLM), although the proportion of private lands in the western part of the management unit increases with proximity to Barstow. Bighorn sheep habitat within the management unit is located primarily in areas of public ownership.

Vegetation

Habitats within the management unit are typical of the Mojave Desert, and consist largely of desert scrub and desert wash (Mayer and Laudenslayer 1988). Creosotebush (*Larrea tridentata*) dominates desert scrub, and smoke tree (*Psoralea argemone*) and catclaw (*Acacia greggii*) are important species in desert wash habitats (Paysen et al. 1980). Blow-sand areas support extensive stands of big galleta (*Hilaria rigida*) and Indian ricegrass (*Oryzopsis hymenoides*) (Wehausen 1990).

Water

Water is extremely limited within the Cady Mountains Bighorn Sheep Management unit. The Mojave River flows through Afton Canyon and currently provides a perennial source of surface water that is used extensively by bighorn sheep, and bighorns seek out the shade provided by deep gullies near Afton Canyon (Wehausen 1990). Continuous flows of water through Afton Canyon and, hence, availability of that resource to bighorn sheep is no longer a certainty assured because of up-stream pumping of groundwater that has resulted in decreased surface flows along the Mojave River.

Two wildlife water developments have been constructed in the management unit in cooperative efforts between the California Department of Fish and Game, Bureau of Land Management, and the Society for the Conservation of Bighorn Sheep. These water developments, installed in 1970 and in 1982, provide perennial surface water (except during years of rainfall inadequate to provide runoff to recharge the catchments) and are used heavily by bighorn sheep. Currently 100% of all maintenance on these units is performed by volunteers affiliated with the Society for the Conservation of Bighorn Sheep.

RANGE CONDITIONS

Range conditions in desert habitats are quite variable from year to year, season to season, and area to area, and are a function of the amount and timing of rainfall (Noy-Meir 1973). The BLM rated range conditions as fair in 1980 (U. S. Bureau of Land Management 1980), and range conditions were described as poor by Wehausen

(1990), based on low plant diversity, the then-current drought, and apparent overuse by cattle.

Livestock

A large portion of the Cady Mountains was included in the Afton Canyon Grazing Allotment, but that ephemeral allotment has been vacant since 2005 and the current permit holder's base property has been purchased by the Department of Defense (A. Chavez, Bureau of Land Management, personal communication, 14 October 2010). Should the permit holder elect to relinquish grazing privileges on the Afton Canyon Grazing Allotment, "... BLM would, without further analysis or notice; not reissue the lease; remove the allotment designation; assume any and all private interest in range improvements located on public land; and, designate the land as no longer available for livestock grazing" (Bureau of Land Management 2005).

Although cattle have not grazed within the management unit since 2005, Wehausen (1980) noted that competition with bighorn sheep was likely near Afton Canyon during the hot season because of the forage, shade, and water resources found there. In 1986, the initial wildlife water development was fenced (Helvie 1971) because cattle had begun using it. Since the fence was completed, no use of the guzzler by cattle had been observed; cattle have not been known to use the wildlife water development built in 1982.

Feral Animals

With the exception of a small number of horses (*Equus caballus*) and donkeys (*Equus asinus*), no feral animals are known to inhabit the Cady Mountains Management Unit. These few feral horses were last known to have been observed in 1986, and apparently posed no management problems. It is not known whether horses or donkeys persist in the Cady Mountains but, if they do, they likely do not occur in large numbers and continue to pose little, if any, threat to bighorn sheep.

Habitat Improvements

Following recommendations of Weaver et al. (1969), a wildlife water development was installed in the southern portion of the Cady Mountains in 1972. In 1982, a second wildlife water development was installed to increase availability of suitable summer habitat within the management unit. Each of these developments provides water throughout the year, and each receives extensive use by bighorn sheep. These two habitat improvement projects were cooperative efforts among the Department of Fish and Game, Bureau of Land Management, Society for the Conservation of Bighorn Sheep, and the San Bernardino County Fish and Game Commission. Currently, 100% of the maintenance necessary to ensure the functionality of these wildlife water developments is carried out by individuals affiliated with the Society for the Conservation of Bighorn Sheep.

Other Human Influences

The most important human influences on bighorn sheep inhabiting the Cady

Mountains Management Unit have been activities associated with construction of interstate highways 15 and 40, use of Afton Canyon by the Santa Fe-Southern Pacific Railroad, cattle grazing in the northern portion of the mountain range, and recreational activities in the vicinity of Afton Canyon, where a public campground is located at the southern terminus of Afton Road. Additionally, the Mojave Road parallels the Mojave River through Afton Canyon and generates substantial public interest. This route has been widely publicized (Casebier 1983), and vehicle traffic is extremely heavy at times. Other recreational activities are limited within this management unit, but include recreational prospecting and mining, hunting for upland game and predators, and commercial trapping, all of which are compatible with conservation objectives for bighorn sheep.

Construction of Interstate Highway 15 in the early 1970s probably restricted bighorn movements to and from mountain ranges to the north of the Cady Mountains Management Unit, especially the Cronese and Soda mountains. Likewise, construction of Interstate 40 probably restricted movements to and from mountain ranges to the south, including the Rodman, Bullion, Newberry, Lava Bed, and Ord mountains. Movement corridors between mountain ranges are important components of bighorn habitat (Schwartz, et al. 1986; Bleich et al. 1990, 1996; Epps et al. 2007). Unfortunately, the interstate highways already exist and, as a result, genetic interchange with populations of bighorn sheep to the north and south of the Cady Mountains probably is limited (Epps et al. 2005). Nevertheless, opportunities for movement to and from the Bristol Mountains, Old Dad Peak, and the Kelso and Granite mountains as yet remain unimpeded (Epps et al. 2007).

In 1992, 21 bighorn sheep were translocated from Old Dad Peak to the Bristol Mountains, located immediately east of the Cady Mountains (Torres et al. 1993). The intent of that translocation was to establish a permanent population in the Bristol Mountains and to facilitate interchange of genetic material among bighorn sheep inhabiting the Cady Mountains and areas further east.

Plans are underway to construct a large solar plant on the south side of the Cady Mountains, which would eliminate 8 km² of bighorn sheep habitat (U.S. Bureau of Land Management and California Energy Commission 2010). Development of this facility would further lessen the probability of movements by bighorn sheep across Interstate Highway 40 between the Cady Mountains and those ranges to the south of the highway (U.S. Bureau of Land Management and California Energy Commission 2010). Additional solar plants have been proposed within the management unit, and pose similar threats to connectivity, particularly between the Cady Mountains and the Bristol Mountains.

THE BIGHORN POPULATION

DISTRIBUTION AND HABITS

Based upon aerial telemetry locations and field observations, female bighorn sheep used an area of approximately 143 km² within the management unit in the late 1980s (Wehausen 1990). At that time, preliminary observations indicated that females

confined much of their activity to the northern portion of the Cady Mountains, but Wehausen (1990) speculated that males occupied a range approximately double that of the females. In the absence of additional telemetry investigations, further knowledge of the distribution of bighorn sheep in the Cady Mountains has been slow to accumulate. Currently, bighorn sheep range throughout the Cady Mountains, and observations suggest that females with lambs frequent the more precipitous areas north of Hidden Valley and west of the northernmost wildlife water development during spring. Male bighorn sheep appear to move throughout the Cady Mountains.

No movements of bighorn sheep of either sex out of this management unit have been recorded. Extended movements would be most likely to occur between the Cady Mountains and the Bristol Mountains to the east (Epps et al. 2007; Figure 1), and several individuals translocated from Old Dad Peak to the Bristol Mountains in 1992 moved between that range and the Cady Mountains while telemetry collars remained functional. Additionally, observations of bighorn sheep in the Bristol Mountains prior to the aforementioned translocation suggest that such intermountain movements were ongoing, but all animals observed in the Bristol Mountains reportedly were males (V. C. Bleich, unpublished data). Movements across Interstate Highway 15 and Interstate Highway 40 to or from ranges to the north or south of the Cady Mountains are possible and may still take place, although such movements likely occur less often than prior to highway construction (Epps et al. 2005).

POPULATION DYNAMICS

Population Size and Trends

R. A. Weaver (California Department of Fish and Game [retired], personal communication) has suggested that the bighorn population on the Cady Mountains Management Unit was larger in the early 1900s, and then declined substantially. He based his supposition on early reports by workers that observed groups of up to 40 bighorn sheep along the railroad in Afton Canyon.

In 1940, D. D. McLean (unpublished data) estimated a population of 10 bighorn sheep inhabited the Cady Mountains and adjacent Cave Mountain, and he increased that estimate to 20 in 1946. In 1957, F. L. Jones (unpublished data) estimated that 35 bighorn sheep inhabited the same area. Based upon more extensive surveys than those carried out by either McLean or Jones, Weaver et al. (1969) estimated that 25 bighorn sheep occupied the Cady Mountains (Table 1).

During helicopter surveys conducted in May of 1986 and 1988, 24 and 23 bighorn sheep, respectively, were observed in the management unit, and the population estimate was raised to 50 (Weaver 1986, 1988; Table 1). Using a mark-recapture methodology, Wehausen (1990) estimated that 25 adult female bighorn sheep, and an undetermined number of males, inhabited the Cady Mountains in 1989. Subsequently, Torres et al. (1994) placed the Cady Mountains population in the South-Central Mojave Metapopulation, with an estimate of 25-50 bighorn sheep inhabiting the mountain range. In the absence of data to the contrary, both Torres et al. (1996) and Epps et al. (2003) retained the same population estimate (25-50) for the Cady

Mountains (Table 1).

In 2007, a helicopter survey yielded observations of 109 bighorn sheep in the Cady Mountains (Table 2). A more structured survey, conducted in 2009, yielded observations of 167 bighorn sheep, and a minimum population of 207 bighorn sheep was estimated to inhabit the Cady Mountains (Table 2). In October 2010, the 2009 survey was replicated and yielded observations of 174 bighorn sheep (Table 2). Aerial surveys seldom, if ever, yield observations of all animals that are present (Graham and Bell 1987), and observed numbers must be corrected for visibility bias. Application of a very conservative visibility correction factor (0.8) indicates that a minimum of 200 bighorn sheep (and likely substantially more) currently occupy the Cady Mountains. Thus, the population of bighorn sheep inhabiting the Cady Mountains is substantially greater than that anticipated by Epps et al. (2003).

Population Structure

There is limited historical information about the structure or dynamics of this population of bighorn sheep. All available information indicates that the population was smaller in the 1940s, 1950s, and 1960s than at the present time (Table 1). R. A. Weaver (personal communication) has speculated that the cumulative impacts of vehicle activity, cattle grazing, and continual operation of the railroad through Afton Canyon, have impacted the bighorn sheep population in the north end of the Cady Mountains.

Field work in the Cady Mountains has not been extensive, and is limited to the report of Wehausen (1990) in which he used a mark-resight approach to estimate that 25 (95% CL = 17-43) female bighorn sheep inhabited the Cady Mountains. Wehausen (1990) also estimated the Cady Mountains to have the lowest population density (0.2 ewes [95% CL = 0.1 – 0.3] per km²) of the 5 desert mountain ranges he studied in the region, and cited low plant species diversity, impoverished forage resources resulting from drought, and cattle grazing as factors contributing to the low density of bighorn sheep on this management unit.

Very little information on the sex and age structure of the population was gathered prior to 1986; since then, 5 helicopter surveys have been conducted (Table 2). In general, male to female ratios are high, as expected in an unmanipulated population of polygynous ungulates. The male to female ratio ranged from 41 to 64 males per 100 females, based on aerial surveys conducted in 2007, 2009, and 2010 (Table 2).

Mortality Factors

Diseases and Parasites

Blood samples were taken from bighorn sheep captured and collared in this management unit in 1986 and 1988 as part of an extensive survey of diseases and parasites of bighorn sheep (Clark et al. 1985). Of 14 blood samples collected, 100% tested positive for chlamydia, 39% for respiratory syncytial virus, 36% for bluetongue (BT), 31% for both epizootic hemorrhagic disease (EHD) and bovine viral diarrhea, and 8% tested positive for parainfluenza-3. No evidence of exposure was found to

brucellosis, infectious bovine rhinotracheitis, leptospirosis, or lungworms. Although Wehausen (1990) described the population of bighorn sheep as having had substantial exposure to bluetongue and PI-3, he was unable to confirm that high levels of exposure to BT or EHD were responsible for the low population density in that range, and speculated that the low density of bighorn sheep was a consequence of poor forage resources.

Predation

There are no records or other indications that predation poses a problem to the bighorn sheep population on this management unit.

Other Mortality Factors

Bighorn sheep occasionally are killed by trains on the railroad tracks in Afton Canyon. The most recent such mortality is thought to have occurred in 2004; it is unlikely these infrequent losses affect dynamics of the population.

TRANSLOCATIONS

To date, there have been no translocations of bighorn sheep into or out of this management unit. However, 21 bighorn sheep were translocated to the Bristol Mountains, located east of the Cady Mountains, in 1992. At least 3 of those animals made intermountain movements to and from the Cady Mountains, demonstrating that opportunities for connectivity between those ranges remained. Prior to that translocation, bighorn sheep (or their sign) infrequently had been reported in the Bristol Mountains; notes associated with those observations suggest that bighorn sheep seen in the Bristol Mountains originated in the Cady Mountains (V. C. Bleich, unpublished data). Currently, the population of bighorn sheep inhabiting the Cady Mountains is of sufficient size to provide translocation stock for establishing or augmenting bighorn sheep populations in other portions of the Mojave Desert.

RECOMMENDATIONS FOR ACHIEVING MANAGEMENT GOALS

Section 4900 of the Fish and Game Code declares it ... "to be the policy of the state to encourage the preservation, restoration, utilization, and management of California's bighorn sheep population," and that, "management shall be in accordance with the policy set forth in Section 1801" (of the Fish and Game Code). To fulfill that policy and to achieve management goals for bighorn sheep on the Cady Mountains Management Unit, the following recommendations should be implemented.

1. This bighorn sheep population should continue to be monitored carefully. Aerial surveys should be conducted in autumn each year to estimate population size and trends, structure, and rate of recruitment of lambs into the population. Annual surveys should be structured so that the same areas are flown at the same intensities in order to derive meaningful estimates of catch per unit effort and maximize opportunities to detect changes in population trends and (Wehausen and Bleich 2007). A sufficient sample (6-10 years) of continuous survey data may allow the development of models that can be used to project

estimates of population size forward 1-2 years and preclude the necessity of annual surveys in the future (Conner 2009, 2010).

2. Every effort should be made to manage for at least 50 adult females, and to maintain a minimum ratio of 40 males to 100 females in this population, yielding an effective population size large enough to minimize the loss of genetic variability over the short term (Franklin 1980).
3. If bighorn sheep are captured on this management unit, blood and other samples should be collected for serological and other examinations to monitor the incidence of diseases, parasites, and, potentially, changes in rates of infection. Appropriate samples for use in genetic investigations should also be collected whenever individual animals are handled, and archived for use by future investigators.
4. The two existing wildlife water developments currently are inspected, maintained, and repaired twice a year by individuals affiliated with the Society for the Conservation of Bighorn Sheep. These efforts must continue to ensure that water is available at those wildlife water developments for use by bighorn sheep and other wildlife. The Department of Fish and Game must commit to providing personnel necessary to offset any decline in the ability of volunteers to inspect and maintain the existing wildlife water developments, and should reestablish the position of desert water coordinator to direct and oversee the activities of citizen groups interested in the conservation of bighorn sheep.
5. Because of the high level of interest in bighorn sheep, every effort should be made to keep the public informed of the status of this population. Information can be disseminated through the Department's public information officers, news releases, popular and technical articles, the Department's web site, and other appropriate methods.
6. The Department should expand its cooperation with citizen groups that support and encourage sound management of bighorn sheep. The Department should continue to request assistance from experienced citizens to conduct, inspections, make repairs and improvements of existing water sources, and install new water sources, and to conduct surveys necessary for the management or conservation of bighorn of bighorn sheep. The Department has had long-standing and successful relationships with several citizen groups dedicated to conservation of bighorn sheep and other wildlife, including the Society for the Conservation of Bighorn Sheep, Desert Wildlife Unlimited, the Volunteer Desert Water and Wildlife Survey, and the California Chapter of the Wild Sheep Foundation. Continued participation of citizen groups is vital to the successful conservation of bighorn sheep in California.
7. The Department should reestablish the position of desert water coordinator to direct and oversee the activities of citizen groups interested in the conservation of bighorn sheep. The position has not existed for more than 5 years, and

continued participation by citizen groups will be contingent upon the Department playing a leadership role with respect to volunteer activities.

8. In keeping with the overall policy of the California Department of Fish and Game, this population should be considered in the context of its potential to provide recreational uses, including opportunities to harvest a limited number of mature males.
9. To minimize the potential for further impacts to intermountain movements by bighorn sheep occupying the management unit, the Department should make every effort possible to influence the design, construction, and operation of proposed solar plants to protect bighorn sheep habitat, particularly potential travel corridors.
10. To keep this management plan current, annual reviews should be prepared. At a minimum, those reviews should include: (a) results of any aerial or ground surveys, distributional data, and age and sex composition of the population; (b) results of any capture or translocation efforts; (c) a report of water conditions, including any maintenance or improvements performed; (d) a summary of recent disease information; (e) a summary of any telemetry or other research results; and (f) a summary of any habitat disturbances, poaching, harassment, or other factors that might be detrimental to the population; (g) a summary of management actions anticipated to occur in the upcoming year; and (h) recommended management actions to correct any problems identified during the previous reporting period.

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Table 1. Number of bighorn sheep estimated to inhabit the Cady Mountains, San Bernardino County, California, 1940 – 2010

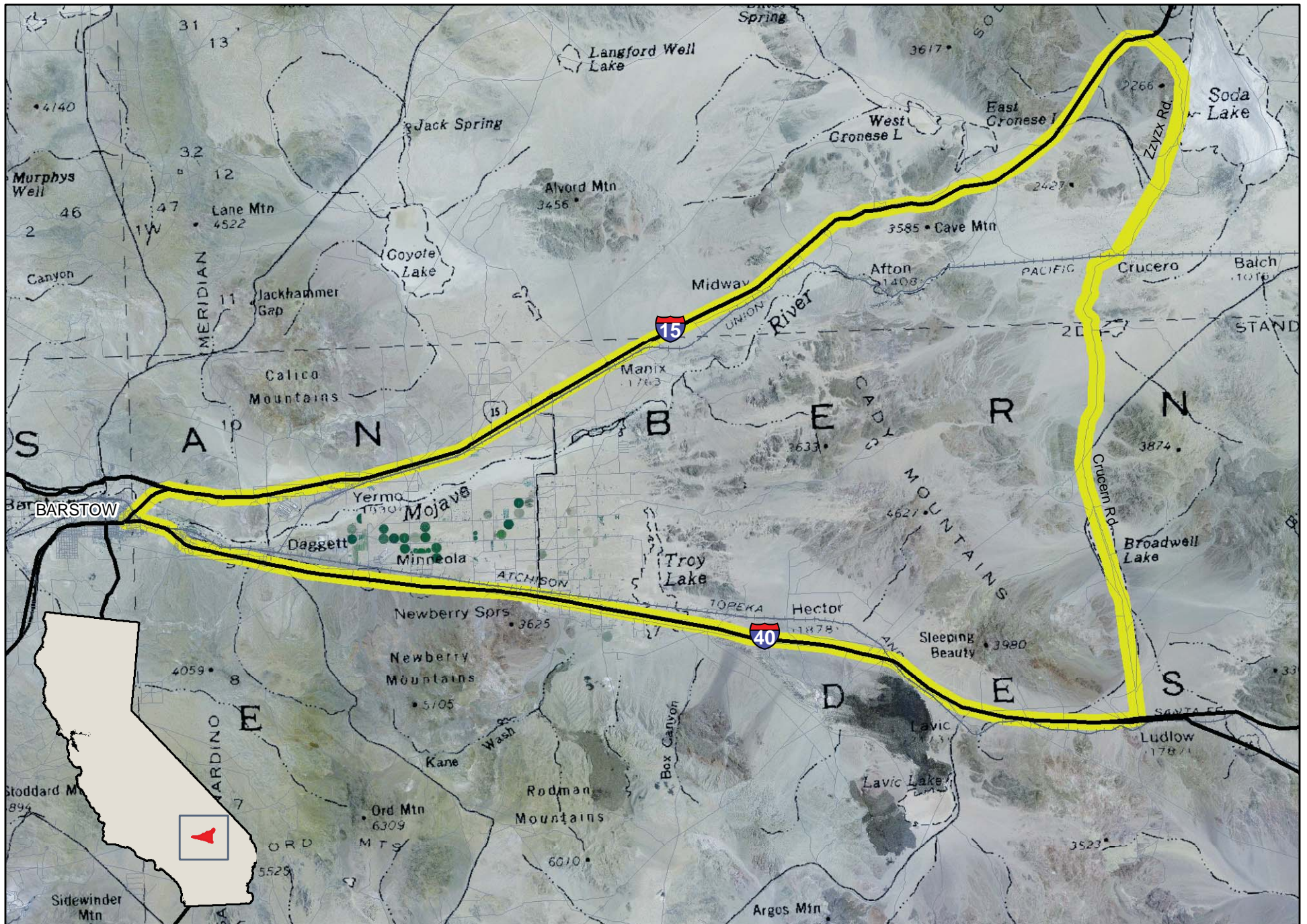
Year	Estimated number of bighorn sheep	Authority
1940	10	D. D. McLean (unpublished data)
1946	20	D. D. McLean (unpublished data)
1957	35	F. L. Jones (unpublished data)
1969	25	Weaver et al. (1969)
1986	50	Weaver (1986)
1988	50	Weaver (1988)
1990	25*	Wehausen (1990)
1993	25-50	Torres et al. 1994
1995	25-50	Torres et al. 1996
2003	25-50	Epps et al. 2003
2007	100-150*	A. M. Pauli (unpublished data)
2009	217**	A. M. Pauli (unpublished data)
2010	209**	A. M. Pauli (unpublished data)

* Females only; numbers of males and young are not included in this estimate.

** Minimum number of bighorn sheep estimated to be present following application of a conservative (0.8) correction factor.

Table 2. Sex and age classification of bighorn sheep observed during aerial surveys in the Cady Mountains Management Unit, 1969-2010

Date	Ewes	Lambs	Rams	Uncl.	Total
1/16/1969	2	1	1	0	4
5/9/1984	0	0	0	19	19
5/24/1984	1	0	0	5	6
5/20/1986	5	2	17	0	24
9/6/1988	11	2	10	0	23
10/18/2007	59	12	38	0	109
9/23/2009	92	37	38	0	167
10/6/2010	102	23	49	0	174



Cady Mountains Management Unit

